DIVERSITY AND ECOLOGY OF ANURANS AT SELECTED STREAMS IN TAMAN NEGARA JOHOR ENDAU ROMPIN, MALAYSIA

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DEDICATION

Thanks for all these years for being with me. Lot of love for my father Awang Abu Bakar dan my mother Maimunah binti Nawi

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ABSTRACT

Malaysia is fortunate and proud to become one of the world's greatest centers of biodiversity. It has a lot of tropical rainforest and one of the examples is Taman Negara Johor Endau Rompin (TNJER). TNJER has been recognized as one of the special areas since the early 1950s due to the uniqueness of its forest, the richness of its biodiversity and the invaluable beauty of its nature. In addition, the forest is estimated to be at least 248 million years old based on the features of rock formations. This study was carried out only at Peta area, for nine months. This study only focused on three streams namely; Sungai (Sg.) Da'ah, Sg. Semawak, and Sg. Kawal using the Visual Encounter Survey (VES) method. Twenty species of anurans, belonging to 15 genera and five families, were documented in this study. Ranidae is the richest families, followed by Bufonidae, Microhylidae, Dicroglossidae and Rhacophoridae. In addition, an updated checklist of anuran fauna has been produced listing a total of 54 species with two locality records for TNJER, namely *Microhyla palmipes* and *Philautus petersi*. Besides, the endemic species; *Ansonia endauensis* and *Ingerophrynus gollum* still can be found during the sampling time. The results indicated that all species within the three streams have low dominancy and the species are evenly distributed. Meanwhile based on estimators, there is a possibility of adding up one to seven more species to the species community. From the evaluation of the estimators, ACE and Chao 1 seem to be the most reliable estimators among seven others. These findings are very useful, as they contribute to a better understanding of anuran diversity in TNJER, and can become a reference point in understanding more about the overall diversity of anuran species in Johor.

ABSTRAK

Malaysia amat bertuah dan seharusnya berbangga kerana menjadi salah satu pusat biodiversiti terbesar di dunia. Ianya mempunyai banyak hutan hujan tropika dan salah satu contoh adalah Taman Negara Johor Endau Rompin (TNJER). TNJER telah diiktiraf sebagai salah satu kawasan khas sejak awal tahun 1950an disebabkan oleh keunikan hutannya, kekayaan biodiversiti dan keindahan alam semula jadi yang tidak ternilai. Di samping itu, umur hutan ini dianggarkan sekurang-kurangnya 248 juta tahun berdasarkan ciri-ciri formasi batu. Kajian ini telah dijalankan hanya di kawasan Peta, selama sembilan bulan. Kajian ini hanya memberi tumpuan kepada tiga anak sungai iaitu; Sungai (Sg.) Da'ah, Sg. Semawak, dan Sg. Kawal menggunakan kaedah keternampakan secara visual (VES). Melalui kajian ini, 20 spesies anurans, terdiri daripada 15 genera dan lima keluarga, telah didokumenkan. Ranidae merupakan keluarga yang terkaya, diikuti oleh Bufonidae, Microhylidae, Dicroglossidae dan Rhacophoridae. Di samping itu, senarai semakan fauna anuran yang telah dikemaskini telah dihasilkan yang memberikan sejumlah 54 spesies dengan dua rekod tempatan untuk TNJER, iaitu *Microhyla palmipes* dan *Philautus petersi*. Selain itu, spesies endemik; *Ansonia endauensis* dan *Ingerophrynus gollum* masih boleh didapati semasa masa pensampelan. Selain itu hasil kajian mendapati bahawa semua spesies dalam tiga sungai mempunyai dominasi yang rendah dan spesiesnya sama rata. Sementara itu berdasarkan penganggar, terdapat kebarangkalian untuk menambahkan satu hingga tujuh spesies lagi kepada komuniti spesies. Namun, melalui penilaian beberapa penganggar, ACE dan Chao 1 merupakan penganggar paling dipercayai di kalangan tujuh yang lain. Penemuan dalam kajian ini sangat berguna, kerana ianya menyumbang kepada pemahaman yang lebih baik mengenai kepelbagaian anuran di TNJER, dan boleh menjadi titik rujukan untuk memahami lebih lanjut tentang kepelbagaian spesies anuran di Johor.

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LIST OF ABBREVIATIONS

ASG	-	Amphibian Specialist Group
CoR-SUNR	-	Centre of Research Sustainable Uses of Natural
DAPTF	-	Declining Amphibians Populations Task Force
IUCN	-	International Union for Conservation of Nature
MEA	-	Millennium Ecosystem Assessment
NERC	-	Nature Education and Research Centre
PA	-	Protected area
PAST	-	PAleontological STatistics
JNPC	-	Johor National Park Corporation
Sg	-	Sungai
S_{obs}	-	Species observed
SRE	-	Species richness estimators
TNJER	-	Taman Negara Johor Endau Rompin
VES	-	Visual Encounter Survey

LIST OF PUBLICATIONS

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i. **Awang, M. T**., & Maryati, M., (2016). Kepelbagaian Anuran, Pemuliharaan dan potensi sebagai petunjuk biologi di Taman Negara Johor Endau Rompin in *Kolokium Pengurusan dan Pembinaan (Siri 1) 2016 on 20 January 2016 at Hotel Katerina, Batu Pahat, Johor.*

ii. **Awang, M. T**., Maryati, M., & Lili, T. (2016). The Night Attraction, Anurans: (Frogs and Toads) in Taman Negara Johor Endau Rompin in *Seminar Biodiversiti 2016 on 21-25th November 2016 at Awana Hotel, Genting Highlands, Pahang.*

iii. **Awang, M. T**., Maryati, M., Othman, M. N. A., Lili, T., & Jefri, I. (2017). A preliminary survey of Anurans at Sungai Ulu Bekoh and Sungai Dok, Ledang, Tangkak in *Seminar Warisan Semulajadi Johor 2017 on 13 – 14 March 2017 at M Suite Hotel, Johor Bahru, Johor.* **(In press.)**

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i. **Awang, M. T**., Maryati, M., & Lili, T. (2016). Diversity of Anurans, Conservation Effort and its Potentials as Bioindicator in Taman Negara Johor Endau Rompin *in Joint Seminar on Biodiversity and Conservation (JSBC 2016) on 8th April 2016 at Universiti Gadjah Mada, Yogyakarta, Indonesia*.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia is fortunate and proud to become one of the world's greatest centres of biodiversity, with approximately 185,000 species of fauna and 12,500 species of flowering plants (Normah *et al*., 2011). One of the examples of a tropical rainforest in Malaysia is Taman Negara Johor Endau Rompin (TNJER). It is located at the southern end of Peninsular Malaysia and situated between two states, Johor with the area of 48,905 ha (Chew, 2007), and Pahang with the area of 38,780 ha (Kiew, 1987). The park has a gazetted area of 48,905 hectares in total which then were divided into two parts; Taman Negara Endau Rompin (Peta) and Taman Negara Endau Rompin (Selai). Endau Rompin (Peta) encompasses about 19,562 hectares (40% of the total gazetted area) with an entrance from Kahang, Mersing. Meanwhile, Endau Rompin (Selai) encompasses about 29,343 hectares (60% of the total gazetted area) with an entrance from Bekok, Segamat. TNJER has been gazetted as a National Park since 1993 (Shahriza *et al*., 2012) and currently managed by Johor National Park Corporation (JNPC); an organization set up under the National Parks Johor Corporation Enactment 1989. In addition, TNJER has been recognized as one of the special areas since the early 1950s due to the uniqueness of its forest, the richness of its biodiversity and the invaluable beauty of its nature. It is claimed to be one of the oldest tropical rain forests in the world. The forest is estimated to be at least 248 millions years old based on the features of rock formations (Shariza *et al*., 2012). It is characterized by mixed dipterocarp rainforest, crisscrossed by a network of several small streams that

eventually merge into the main rivers (Wood *et al*., 2008). Among the main rivers found here are Sungai (Sg.) Endau, Sg. Kinchin, Sg. Segamat, Sg. Selai and Sg. Jasin. The weather in TNJER is generally hot and humid all year round, as the temperature ranges between 25°C and 33°C. The rainy season is usually between December to January. The average annual rainfall in TNJER is 3000 mm to 3,400 mm. Due to the humid climate, TNJER becomes the most important refuge for wildlife in southern Peninsular Malaysia. It is regarded as the home for at least 95 species of mammals, 250 species of birds, and 76 species of fish (Chew, 2007). Several endangered species, such as *Elephas maximus* (Asian Elephant), *Panthera tigris* (Malayan Tiger) and *Tapirus indicus* (Malayan Tapir), were also found here (Shahriza e*t al*., 2012). Not to mention, there are 52 species of anurans recorded here (Maryati *et al*., 2016)

Amphibian is a class of vertebrates, comprising three orders: a) Anuran; frogs and toads, b) Caudata; salamanders and newts, and c) Gymnophiona; caecilians. Amphibians are believed to originate from a branch of bony fishes (Class: *Sarcoptergyii*, Subclass: Dipnoi, lungfishes) during the Devonian period about 419.2 million years ago (Nelson, 2006). They earned the name amphibian, not because they go in or out of water, but because they begin their life as tadpoles, metamorphosise to adults and live on land (Badger, 2011). Different stages of life cycles have given them the advantage to utilize both terrestrial and aquatic habitats. In the tadpole stage, they forage in the aquatic environment meanwhile in adult stage they like to eat insects. Amphibians have been dominating this planet for roughly 350 million years. Assessments of the world's amphibians (Stuart *et al*., 2004; 2008) found that nearly a third of the known species of amphibians are globally threatened with extinction and at least 42% of known amphibian species are experiencing population losses (Whittaker *et al*., 2013). There are incidences of some species that have gone extinct in the last two decades, indicating that the number of threatened and extinct species would probably continue to rise (Stuart *et al*., 2004). The greatest threat to tropical biodiversity is the rapid loss and fragmentation of old-growth forests (Lovejoy *et al*., 1986; Sodhi *et al*., 2004; Laurance & Peres, 2006). Additionally, logging is also one of the main causes of biodiversity loss in tropical forests. Logging causes changes in forest structure, disturbance, and dislodgement of animals from their habitats, gap opening, and loss of food resources (Lagan *et al*., 2007).

1.2 Problem Statement

Johor is one of the fastest developing states in Malaysia with rapid urbanization and agriculture advancement. Many development projects are underway to increase the economics of Johor, such as the Forest City; a project rising out of four artificial islands in the Strait of Tebrau off the southwestern coast of Johor (Rahman, 2017). Although urbanization and industrialization of agricultural areas provide economic benefits to people, it also leads to destruction of amphibian habitats (Meyer & Turner, 1992). Since TNJER is the largest piece of protected area in the southern part of Peninsular Malaysia, all of the information about the flora and fauna that are present need to be documented well which includes the anuran species. This means that a baseline data is urgently needed if conservation is going to be one of the main state's government agenda in its remaining forests. TNJER has become a strict nature reserve with no more timber exploitation since 1972. JNPC can come out with a strategic plan to propose to the state government, in order to conserve TNJER for the survival of wildlife living within the park. This would ensure that TNJER is preserved for the benefit of future generation so that they can experience Malaysia's heritage first hand.

1.3 Aim and Objectives of the Study

The aim of this research is to establish baseline information of the anuran fauna in a protected area of Taman Negara Johor Endau Rompin. To achieve this, three objectives are outlined below:

(i) To collect, record, and preserve amphibian species to produce an updated anurans checklist and a reference collection for Taman Negara Johor Endau-Rompin (PETA area)

(ii) To measure the diversity index of amphibians from the three selected streams

(iii) To estimate species richness using non-parametric estimators.

1.4 Significance of the Study

This thesis is about documenting the species richness and diversity of anuran fauna in one of the last remaining tropical forests at the southernmost Peninsular Malaysia and

mainland Asia. It also provides a reference collection of anuran samples presently available at Taman Negara Johor Endau Rompin (TNJER). It contains information about anurans at three streams with different habitat characteristics, therefore enhancing our ecological knowledge of these animals. This research also provides a baseline information on species richness and diversity of anuran fauna in TNJER. Findings from this thesis would be helpful in the management of TNJER. There was an increase in anuran species discovered from 24 in 1985 to 52 species in 2016. The number of species obtained from this study indicates that with continuous sampling, covering larger sampling areas, the current anuran checklist of TNJER would consequently expand. There are two new locality records, namely *Microhyla palmipes* (Boulenger, 1897) and *Philautus petersi* (Boulenger, 1900). A complete specimen reference collection of anurans from TNJER is now available. Based on these collections and records of previous findings, the checklist of anurans of TNJER totals 52 species from the total of 107 species of anurans in the Peninsular Malaysia (Chan *et al*., 2010).

The second aspect of this study was to measure the diversity index of amphibians from the three selected streams in which the condition of the three streams is different. Sg. Da'ah is the closest to Kampung Peta, and local people use its water for daily consumption. Meanwhile, Sg. Semawak is the nearest to NERC (Nature Education Research Centre). NERC is only accessible to researchers. Water source at NERC is being supplied from the Sg. Semawak. Additionally, part of the water supply is being used to run a micro hydro pump. Last but not least, Sg. Kawal is the furthest from any human settlement, thus, the water quality is the best.

The last aspect of this study was to estimate species richness using nine non-parametric estimators. Although the research was done on a small portion of TNJER, some estimators were shown to have a higher value than the actual species obtained. This may be due to the biasness of certain estimators. By doing this analysis, it can be concluded that the sampling effort was sufficient to get all the species. As the government is now developing a new management plan and a business plan, efforts to increase nature tourism becomes an important agenda. To facilitate and promote nature tourism, accurate identification is critical. As shown before, to enable correct identification, a properly identified reference collection is vital. This research and the book written about it could be useful aids in promoting nature tourism or the anuran tourism in TNJER.

CHAPTER 2

LITERATURE REVIEW

2.1 Anuran the Amphibian

The origin of tetrapods provides the major evolutionary shift as they started to move out from water to land, from gills to lung-breathing and from swimming to walking and running during the Devonian period (Thomson, 1993). The first tetrapod was said to evolve from bony fishes from class: Sarcoptergyii, subclass: Dipnoi, lungfishes (Nelson, 2006). The earliest tetrapod fossil was found from the Devonian period in Greenland (Save-Soderbergh, 1932; Jarvik, 1980). The specimen had features intermediate between late Sarcoptergyii fishes and early amphibians. Due to that reason, Amphibia was believed to be the first terrestrial vertebrates that had successfully colonized the land. The term Amphibia was derived from Greek word "amphibious" means "both lives" (O'Rourke, 2007). The life cycle begins from the tadpoles which then will undergo metamorphosis to become adult amphibians. There are three orders of living amphibians that can be found in a variety of aquatic and terrestrial environments throughout the world. The first order is Gymnophiona (gymnos, means naked while ophineos, means snake) where elongated, limbless organisms are grouped. An example would be caecilians. Next, order Urodela (oura, means tail while delos, means evident) comprise of tailed amphibian. These include salamanders and newts. Lastly, order Anura (a, means without while oura, means tail), is more commonly known as frogs and toads. Amphibians have a unique characteristic that distinguish them from other vertebrate classes. One of the unique characteristic is that amphibians are ectothermic organisms. They are known to be very sensitive due

to their skin being permeable to water. Consequently, they are dependent on the environmental temperature to achieve the optimum body temperature (Zachos *et al*., 2001; Walter *et al*., 2002). Thus, as the environment changes, amphibians will be the first organism that would be affected (Beebee *et al*., 1990). For example, an increase in global temperature would affect physiology, reproduction, ecology, and behaviour of the amphibians (Gvozdik & Castilla, 2001; Pough *et al*., 2001; Dorcas *et al*., 2004; Cleland *et al*., 2006).

Anuran comprises of frogs and toads. They show a remarkable body form. The variation of their skin pattern usually related to the life style of each species. There are a few papers that give the general references on external characteristics (Duellman, 1970; Tyler, *et al*., 1984; 1994). Male frogs are generally smaller than females and basically, all toads are also known as frogs. The term "toad" only applies to a species that had squat bodies, short hind legs, little webbing on the feet, have parotid glands behind the eyes, with dry and warty skin. Frogs are very common and widely distributed in every part of the world. Most people had probably encountered them at an early age, whether they saw them near a pond, or at the drainage outside their house. Frogs and toads have their own attraction to fascinate the human eye. Some people are amused by the unique skin pattern of frogs while others are attracted to their bright colors such as the Poison dart frogs.

2.2 Diversity of Amphibian worldwide

The total number of described species of amphibians presently available exceeds those of all other land vertebrates. The pattern of increment reveals that the known fauna will continue to grow in the decades to come (Glaw & Köhler, 1998). AmphibiaWeb database currently contains 7,667 amphibian species (AmphibiaWeb, 2017), of which 6,766 are frogs and toads, 696 are newts and salamanders, and 205 are caecilians. Although it is impressive, but the number of species recorded is certainly much below the exact number of amphibian species that still living on earth. Amphibian diversity are expected to continue to rise as new species are being discovered and described every year and even if a few of the new nomina are later shown to be synonyms, the mean increase has been around 100 new species per year in the last decade (Ohler *et al*., 2009). Mittermeier *et al*., (2004) stated that there are 34 places in the world

regarded as the biodiversity hotspots which had high numbers of endemic species but at the same time are undergoing immense habitat loss. Southeast Asia is comprised of Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, Peninsular Malaysia, East Malaysia, the western Indonesian islands of the Sunda Shelf (excluding western New Guinea's Papua Province), the Philippines, Brunei Darussalam, and Singapore. Southeast Asia has four of these biodiversity hotspots namely, Indo-Burma; Sundaland; Wallacea, and the Philippines. Each of these hotspots has a high level of species endemism, very unique and has a complex geological history that probably influenced the contemporary geographical range and local distribution of its ecological aspects (Sodhi *et al*., 2004; Bickford *et al*., 2010). While Southeast Asian forests are mostly tropical or subtropical, it is being inhabited by at least 900 described species of reptiles and 700 described species of amphibians (Das & van Dijk, 2013). These two classes are similar up to a certain degree; as they are able to occupy various types of environments, such as mangroves, rivers, streams, swamps, waterfalls, lakes, primary forests, plantations, caves and mountains including the disturbed areas (Shahriza *et al*., 2011).

2.3 Species diversity of Amphibian in Peninsular Malaysia

Amphibians and reptiles can be found all over Malaysian landscape, from top of mountain ranges, up along foothills to lowland areas such as agriculture lands, villages, towns and cities. They inhabit all types of microhabitat including the subsoil, forest floors and canopy layers of our tropical rainforest. Studies on the amphibian and reptilian fauna (herpetofauna) of Peninsular Malaysia had begun since the 19th century. Earlier checklists done by Butler (1902) and Robinson (1905) accounted for 63 species, and subsequently, Boulenger (1912) published a comprehensive monograph on the herpetofauna of the Malay Peninsula, which was later updated by Smith (1930) and added 21 more species of amphibians. Berry (1975), showed that there were 83 species of amphibians inhabiting Peninsular. Chan-ard *et al*., 1999 in his study recorded 88 frog species and toads and 4 caecilians. Das & Norsham (2007) then updated the checklist with 93 recognized species of amphibians (90 anurans and three caecilians). Last updated amphibian checklist of Peninsular Malaysia was published by Chan *et al*., 2010. The number of species has increased to 107 species and yet there

is no updated checklist from that year onward. However, amphibian studies are still on going in Malaysia, and some papers of new record have been published (Norhayati *et al*., 2011; Shahriza *et al*., 2011; Ibrahim *et al*., 2012; Shahriza *et al*., 2013; Shahriza & Ibrahim., 2014).

New species are continually being discovered every year whether from upland area or from the unknown place to the mountain range such as *Ansonia lumut* (Chan *et al*., 2014), *Ansonia vidua* (Hertwig *et al*., 2014), and *Ansonia smeagol* (Davis *et al*., 2016). Most of the discovery of new species is from the genus Ansonia. The bufonid genus Ansonia Stoliczka is composed of 28 small, scansorial, stream-dwelling species ranging as far north as Myanmar, as far east as the Philippines, and southward through the Thai-Malay Peninsula to Borneo (Chan *et al*., 2014). Consequently, the description of *Ansonia smeagol* brings the total number of described species of *Ansonia* to 29. This may happen due to their lotic lifestyle, as these species are restricted to microhabitats with a consistent flow of water and as such, their distributions are fragmented and circumscribed (Grismer *et al*., 2016). Some of these species are endemic to certain area; *A. jeetsukumarani*, is endemic to the Titiwangsa Mountain Range meanwhile two endemic species; *A. endauensis* and *Ingerophrynus gollum*, comes from the lowland forest of Endau Rompin, Johor in southern Malaysia. Moreover, *Ansonia smeagol*, *A. jeetsukumarani*, *A. lumut*, *A. malayana*, and *A. penangensis* are five species of *Ansonia* which is known to only inhabit the upland habitats of Peninsular Malaysia (Grismer *et al*., 2016). It suggests that the diversity of this genus may be largely underestimated owing to the vast expanses of upland habitats that remain unexplored. Latest discovery of a new species of frog was from Gunung Jerai, Kedah, northwestern Peninsular Malaysia, named *Abavorana nazgul* (Evan *et al*., 2017). Even though at first, the field of herpetology was not very popular among Malaysian scientists but nowadays, it is a rapidly evolving field. These are the examples of continued studies on the amphibian fauna being carried out, indicating that there are younger scientists who are now involved, and show a good potential to become herpetologist experts in the future. Based on all those research, it can be concluded that the number of amphibian species in Peninsular Malaysia is much higher than we initially expected.

2.4 Species diversity of Amphibian at Taman Negara Johor Endau Rompin

In TNJER itself, plenty of research have been done since 1985, and there were some documentation of herpetological studies being carried out. The first study was done by The Malayan Nature Society during the Malaysian Heritage and Scientific Expedition on 1985-1986. This study focused on the Ulu Endau area since the area has not been visited by the herpetologists nor there is any information available on the herpetofauna of the area before 1985. That study managed to collect 24 species of anuran (Kiew, 1987). Meanwhile, one researcher from Singapore, Mr. Lim did his research in the Ulu Kinchin area on Pahang-Johor border during two visits between 12-16 June and 17-21 July 1989. 17 species of anurans were recorded in Ulu Kinchin (Lim, 1989). Following the first expedition, another expedition was held at Endau Rompin State Park in Pahang, organized by the Forestry Department of Peninsular Malaysia (JPSM), Pahang State Forestry Department (JPNP), Universiti Kebangsaan Malaysia (UKM) on 5-8 April 2003. 19 species of anuran were recorded for this expedition (Norhayati & Dionysius, 2004). The next anuran survey done in TNJER was carried out in conjunction with the Second Scientific Findings Expedition located at the South West of Taman Negara Johor Endau Rompin. This expedition was done in collaboration between Johor National Park Corporation and Universiti Malaya (UM). This study was done with four visits; 7th to l0th April 2002, 3rd to 6th May 2002, 17th to 20th May 2002 and 23rd to 30th July 2002 and recorded 30 species of anuran (Daicus & Hashim, 2005). Next, a team of researchers from the La Sierra University conducted their research in the Peta region (04°28.318'N, 101°22.635'E) on 24 to 31 August 2005 and in Selai (02º26.000'N, 103º15.283'E) from 30 August to 5 September 2006. Prior to that study, a total of 34 species with additional two new species of toads, *Ansonia endauensis*, Grismer, 2006 and *Ingerophrynus gollum*, Grismer, 2007 has been recorded (Wood *et al*., 2008). These two species were known to be endemic to Endau Rompin only. In addition, the amphibians and reptiles of Taman Negara Johor, (Peta) were briefly investigated during a scientific expedition organized by the School of Biological Sciences, Universiti Sains Malaysia from 17 to 23 August 2008. From the expedition, a total of 25 anurans species from various sites were recorded (Shahriza *et al*., 2012). An unpublished report of Scientific Expedition Trans Selai-Peta, 2012 was quoted from Kelvin (pers. comm.) with only 12 species were recorded during the expedition. Lastly, a study on anurans was done by UTHM researchers in various sites from the

nearby streams within the Nature Education Research Centre (NERC) to the visitor complex. This study managed to record 21 species of anuran (Maryati *et al*., 2016). To date, there are a total of eight researches (five expeditions and three studies) done throughout TNJER for the past 30 years. Checklist of amphibians recorded by the various institutions is in Table 2.1.

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